AIR QUALITY MONITORING CONSIDERATIONS FOR THE MID-ATLANTIC NETWORK

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Introduction

As part of the National Park Service (NPS) Inventory and Monitoring (I&M) Program's Vital Signs scoping process, the Mid-Atlantic Network (MIDN) will evaluate the need for ambient air quality and air pollution effects monitoring in Network parks. This report contains background and summary air quality information to assist Network staff in that effort. On-site and nearby off-site ambient air quality data were used in conjunction with park-specific resource information to evaluate the following relative to the MIDN: 1) the need for additional ambient air quality monitoring at any Network park, i.e., wet deposition, dry deposition, visibility, and/or ozone monitoring, and 2) the need for air quality effects-related monitoring at any Network park. The results of this evaluation are discussed below.

The evaluation for MIDN parks relied on data collected through a number of Federal- and state-sponsored ambient air quality monitoring programs. Monitor locations, site numbers, and distances from MIDN parks are provided in Tables 1 and 2. Maps displaying monitor locations and graphics summarizing monitoring data are provided in a separate PowerPoint file as an addendum to this report.

The evaluation used products developed by the NPS Air Resources Division (ARD) specifically for the I&M Program. In 2004, the ARD finalized an Air Quality Inventory for I&M parks. The Air Quality Inventory consists of GIS-based maps and associated look-up tables that provide baseline values for a set of air quality parameters for all I&M parks. The values are based on averaged 1995 to 1999 data. Because ozone is a regional pollutant, in most cases the look-up table values are likely representative of ozone concentrations in a park. Greater variability, and uncertainty, may exist for deposition and visibility values, since those pollutants are more likely to be influenced by meteorological differences. Air Quality Inventory products are contained in the NPS Air Atlas (http://www2.nature.nps.gov/air/maps/airatlas/). NPS Air Atlas estimates for select air quality parameters for MIDN parks are provided in Appendix 1 of this report, and a description of those parameters is provided in Appendix 2.

In an ongoing project, ARD contracted with an ozone effects expert to assess the risk of ozone-induced foliar injury on sensitive vegetation in I&M parks. The risk assessments are based on NPS Air Atlas ozone values, the Palmer Z Drought Index and park vascular plant lists. The risk assessments will be posted on the ARD website in summer 2004. In the meantime, the draft risk assessment for the MIDN is attached as Appendix 3.

Wet Deposition

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The network is a cooperative effort between many different groups, including the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey, U.S. Department of Agriculture, and private entities. The NPS is a major participant in NADP/NTN, and the ARD recommends that any new wet deposition site installed in a park meet NADP/NTN siting criteria and follow NADP/NTN monitoring protocols. There are currently more than 200 NADP/NTN sites spanning the continental U.S., Alaska, Puerto Rico, and the Virgin Islands (http://nadp.sws.uiuc.edu/).

The purpose of the NADP/NTN network is to collect data on the chemistry of precipitation in order to monitor geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory in Illinois where it is analyzed for hydrogen (acidity as pH), sulfate (SO_4), nitrate (NO_3), ammonium (NH_4), chloride, and base cations (such as calcium, magnesium, potassium and sodium). NADP/NTN's excellent quality assurance programs ensure that the data remain accurate and precise.

The NADP/NTN has also expanded its sampling to include the Mercury Deposition Network (MDN), which currently has over 35 sites. The MDN was formed in 1995 to collect weekly samples of precipitation, which are analyzed for total mercury. The objective of the MDN is to monitor the amount of mercury in precipitation on a regional basis (http://nadp.sws.uiuc.edu/mdn/).

The Pennsylvania Department of Environmental Protection (DEP), under a cooperative agreement with Pennsylvania State University, has maintained the Pennsylvania Atmospheric Deposition Monitoring Network since 1981. The purpose of the DEP program is to determine how much atmospheric deposition is falling in precipitation in the state (http://www.dep.state.pa.us/dep/deputate/airwaste/aq/acidrain/acidrain.htm). The DEP supports nine wet atmospheric deposition and six wet mercury deposition monitoring sites. The Pennsylvania Atmospheric Deposition Monitoring Network monitors the same parameters, follows the same protocols and uses the same quality assurance programs as NADP/NTN and MDN. More than half of the Pennsylvania Atmospheric Deposition Monitoring Network sites are in the NADP/NTN, and all the Pennsylvania DEP mercury monitoring sites are in the MDN.

Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, annual average wet deposition and concentration of SO_4, NO_3, and NH_4 are higher in the eastern than in the western U.S. At many NADP/NTN sites across the U.S., concentration and deposition of SO_4 have declined in recent years as sulfur dioxide emissions have decreased.

Trends have been variable for NO_3 and NH_4, with concentration and deposition at various sites increasing, decreasing, or showing no overall change.

Shenandoah National Park (NP) and Valley Forge National Historical Park (NHP) have wet deposition monitors on-site; the rest of the parks in the MIDN have either a Pennsylvania Atmospheric Deposition Monitoring Network or a NADP/NTN monitor within 90 km. The 2002 NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network wet deposition values for the MIDN were similar, and were consistent with the 1995 through 1999 Network averages contained in the NPS Air Atlas. Sulfate, NO_3 and NH_4 wet deposition ranged from about 15 to 22 kilograms per hectare per year (kg/ha/yr), 9 to 16 kg/ha/yr, and 1.9 to 3.5 kg/ha/yr, respectively. Converted to sulfur (S) and nitrogen (N), the ranges for the NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network values were 5.0 to 7.3 kg/ha/yr for wet S deposition, and 3.5 to 6.3 kg/ha/yr for wet N deposition. The Air Atlas wet deposition values for MIDN parks were 3.7 to 5.6 kg/ha/yr for S and 3.0 to 4.5 kg/ha/yr for N. The NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network wet concentration values for SO_4, NO_3 and NH_4 ranged from about 1.3 to 2.1 milligrams per liter (mg/l), 0.8 to 1.5 mg/l, and 0.16 to 0.34 mg/l, respectively. Trend results for NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network sites in and near MIDN parks are summarized below.

Arendtsville, PA

An NADP/NTN site was installed at Arendtsville, Pennsylvania (PA00), in 1999. Sufficient data are not yet available to characterize pollutant trends at the site.

Valley Forge NHP, PA

A Pennsylvania Atmospheric Deposition Monitoring Network monitor has been operating at Valley Forge NHP (PA60) since 1982. Data show wet concentration and deposition of SO_4 have decreased substantially, wet concentration and deposition of NO_3 have decreased slightly, and wet concentration and deposition of NH_4 have increased.

Charlottesville, VA
Charlottesville, Virginia, has had an NADP/NTN site (VA00) since 1984. Site data show wet concentration and deposition of SO_4, wet concentration and deposition of NO_3, and wet concentration and deposition of NH_4 have decreased since 1990.

Eggleston, VA
The NADP/NTN site has been operating in Eggleston, Virginia (VA13 (Horton Station)), since 1978. Trend data are only available since 1987. Data showed a decrease in wet SO_4 concentration and deposition, but no apparent trend in concentration and deposition of NO_3 or NH_4.

Green Bay, VA
An NADP/NTN site was installed at Green Bay, Virginia (VA24 (Prince Edward)), in 1999. Trend data are not yet available for the site.

Natural Bridge, VA
An NADP/NTN monitor was installed at Natural Bridge, Virginia (VA99), in 2002. Trend data are not yet available from the site.

Shenandoah NP, VA
The NADP/NTN site at Big Meadows, Shenandoah NP, Virginia (VA28), has been operating since 1981. A review of site data shows concentration and deposition of wet SO_4 have decreased, as has deposition of wet NO_3. There has been no apparent trend in concentration of wet NO_3, concentration of wet NH_4, or deposition of wet NH_4.

The four Pennsylvania MIDN parks, Shenandoah NP and Fredericksburg and Spotsylvania County Battlefields Memorial National Military Park (NMP) have MDN monitors on-site or within 45 km. There is no MDN monitor within 100 km of Appomattox Court House NHP, Booker T. Washington National Monument (NM), Petersburg National Battlefield (NB) or Richmond National Battlefield Park (NBP). Trend analyses have not yet been performed for MDN sites due to the relatively short time that sites have been in operation. The MDN site in Arendtsville, Pennsylvania (PA00), has been operating since 2000, the site in Valley Forge NHP, Pennsylvania (PA60), has been operating since 1999, and sites in Culpeper (VA08) and Big Meadows, Shenandoah NP, Virginia (VA28), were installed in 2002. MDN deposition maps show that, similar to SO_4 and NO_3, wet mercury deposition is higher in the eastern U.S. than in the western U.S. Highest wet mercury deposition values are consistently monitored at sites in Florida and along the Gulf of Mexico.

Dry Deposition
The Clean Air Status and Trends Network (CASTNet) is the nation's primary source for atmospheric data to estimate dry acidic deposition (http://www.epa.gov/castnet/). Established in 1987, CASTNet now comprises over 70 monitoring stations across the U.S. The majority of the monitoring stations are operated by EPA; however, approximately 20 stations are operated by the NPS in cooperation with EPA. Each CASTNet dry deposition station measures weekly average atmospheric concentrations of SO_4, NO_3, NH_4, sulfur

dioxide, and nitric acid; hourly concentrations of ambient ozone; and some meteorological parameters. Dry deposition rates are calculated using atmospheric pollutant concentrations, meteorological data, and information on land use, vegetation, and surface conditions. CASTNet complements the database compiled by NADP/NTN; therefore, CASTNet sites are located at or near NADP/NTN sites. Dry deposition monitoring is more difficult, and more expensive, than wet deposition monitoring; consequently, there are fewer CASTNet than NADP/NTN sites nationwide. Due to the small number of CASTNet sites, it is not possible to develop dry deposition isopleth maps such as those produced by NADP/NTN. Because CASTNet uses different monitoring and reporting techniques than NADP/NTN, the dry deposition amounts are reported as S and N, rather than SO_4, NO_3 and NH_4. In addition, because CASTNet calculates dry deposition based on estimated deposition velocities, there is greater uncertainty in the reported values.

Shenandoah NP has a CASTNet monitor on-site; all other MIDN parks have a monitor within 90 km. Data summaries and trend analyses for CASTNet sites near MIDN parks are provided below. All trend analyses cover the timeframe of 1989 through 2001.

Washington Crossing, NJ

The Washington Crossing, New Jersey, CASTNet site (WSP144) data showed decreasing trends in both dry S deposition and dry N deposition. Total S deposition at Washington Crossing was composed of 47 percent dry deposition and 53 percent wet deposition, while total N deposition was 35 percent dry and 65 percent wet.

Arendtsville, PA

The CASTNet data from Arendtsville, Pennsylvania (ARE128), showed a decrease in dry S deposition but no apparent trend in dry N deposition. According to CASTNet, total S deposition at the site consisted of 54 percent wet and 46 percent dry deposition, while total N deposition was 64 percent wet and 36 percent dry.

Eggleston, VA

Data from the Eggleston, Virginia, CASTNet site (VPI120 (Horton Station)) showed a decreasing trend in dry S deposition, but no apparent trend in dry N deposition. Total S deposition at the site was composed of 48 percent dry deposition and 52 percent wet deposition, while total N deposition was 48 percent dry and 52 percent wet.

Green Bay, VA

The CASTNet site at Green Bay, Virginia (PED108 (Prince Edward)), showed decreasing trends in both dry S deposition and dry N deposition. Total S deposition at the site was composed of 32 percent dry deposition and 68 percent wet deposition, while total N deposition was 33 percent dry and 67 percent wet.

Shenandoah NP, VA

The Shenandoah NP, Virginia, CASTNet site (SHN418) data showed a decrease in dry S deposition but no apparent trend in dry N deposition. CASTNet estimated total S deposition at Shenandoah NP was 60 percent wet and 40 percent dry, while total N deposition was 56 percent wet and 44 percent dry.

Surface Water and Fish Tissue Chemistry

It is generally accepted that surface waters with a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter (μeq/l) are sensitive to acidification from atmospheric deposition. For this evaluation, the NPS Water Resources Division's (WRD) *Baseline Water Quality Data Inventory and Analysis* reports were reviewed for all MIDN parks except Shenandoah NP. For Shenandoah NP, the discussion is based on review of a comprehensive air quality and air pollution effects assessment which was completed for the park in 2003 (NPS. 2003. *Assessment of Air Quality and Related Values in Shenandoah National Park*. Technical Report NPS/NERCHAL/NRTR-03/090; http://www.nps.gov/shen/SHEN_IM/inv_references.htm#air). In addition, state agency and the NPS Research Permit and Reporting System websites were reviewed for reports of any additional, relevant surface water chemistry data. The websites were also reviewed for information pertaining to any chemical analyses conducted on aquatic biota collected in park lakes, rivers, and streams. The results of the review are summarized below.

Pennsylvania has a general, statewide fish consumption advisory to limit ingestion of contaminants from untested fish. In addition, more stringent advisories are in effect for a number of lakes and rivers in the Delaware, Ohio, Potomac and Susquehanna River Basins. These advisories are primarily for mercury, but in some locations, polychlorinated biphenyls (PCBs) or chlordane are also of concern (http://sites.state.pa.us/PA_Exec/Fish_Boat/fishpub/summary/sumconsumption.pdf). In Valley Creek at Valley Forge, it is unlawful to kill or possess any fish species due to PCB contamination. In Virginia, fish consumption advisories are in effect for the James River for kepone and PCBs and in the Shenandoah River for PCBs and mercury (http://www.vdh.state.va.us/HHControl/fishing_advisories.htm).

Appomattox Court House NHP

A review of the 1998 *Baseline Water Quality Data Inventory and Analysis* report for Appomattox Court House NHP indicated no water quality data have been collected inside the park, so acid sensitivity of park surface waters is unknown.

Booker T. Washington NM

The 1997 *Baseline Water Quality Data Inventory and Analysis* report for Booker T. Washington NM contains no data collected within the park boundary. Data collected from 1991 to 1995 at a location on Gill's Creek outside the park had an average pH of 7.5. The NPS Research Permit and Reporting System described an annual water quality monitoring program in the park. Reported average pH values for Gill's Creek and Jack-O-Lantern Branch were 6.8 and 7.3, respectively, indicating surface waters in the park are likely not sensitive to acidification from atmospheric deposition.

Fredericksburg and Spotsylvania County Battlefields Memorial NMP

The 2000 *Baseline Water Quality Data Inventory and Analysis* report for Fredericksburg and Spotsylvania County Battlefields Memorial NMP contains data collected in the park between 1991 and 1996. Average pH values ranged from about 5.5 in some small tributaries to about 6.5 in the larger streams. The low pH values indicate some of the

tributaries could be acid-sensitive, but without ANC data, it is not possible to assess their sensitivity.

Gettysburg NMP and Eisenhower National Historic Site (NHS)

The 1999 *Baseline Water Quality Data Inventory and Analysis* report for Gettysburg NMP and Eisenhower NHS contains data collected at numerous springs and streams in both parks between 1972 and 1980. In addition, the NPS Research Permit and Reporting System discussed water quality data collected between 1991 and 1998 in association with fish and stream invertebrate surveys. All data indicated surface waters in the parks are well-buffered and not susceptible to acidification from atmospheric deposition, e.g., the parks had average pH values of about 7.5 and average ANC values of about 800 μeq/l.

Hopewell Furnace NHS

A review of the 1998 *Baseline Water Quality Data Inventory and Analysis* report for Hopewell Furnace NHS indicated surface water chemistry data have been collected in the park since 1991 at French Creek, Baptism Creek and Sprout Run. All data suggested surface waters in the parks are well-buffered and not susceptible to acidification from atmospheric deposition, e.g., the park had average pH values of about 7.0 and average ANC values of about 150 μeq/l.

Petersburg NB

The 1997 *Baseline Water Quality Data Inventory and Analysis* report for Petersburg NB contains 1996 data for Harrison Creek and Poor Creek. The data indicate surface waters in the park are well-buffered and not susceptible to acidification from atmospheric deposition, e.g., the creeks had average pH values of about 6.8.

Richmond NBP

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Richmond NBP showed limited in-park data collected prior to 1999, most of which were collected to assess the presence of landfill leachate in park streams. The NPS Research Permit and Reporting System discussed data collected at 15 sites in the park between 2001 and 2002. The data indicated most sites had pH values below the state standard. The low values were attributed to high concentrations of organic acids from park wetlands. The Drewry's Bluff stream, however, had high ANC values. The data suggested park surface waters are not susceptible to acidification from atmospheric deposition.

Shenandoah NP

The 2003 report, *Assessment of Air Quality and Related Values in Shenandoah National Park*, describes how stream water chemistry has been monitored in the park since 1979 as part of the Shenandoah Watershed Assessment Study. The study was designed to improve understanding of watershed processes and biogeochemistry in the park. Fourteen watersheds are currently monitored on a regular basis. The data indicate underlying bedrock plays an important role in watershed acid sensitivity in Shenandoah NP. Many of the streams on the acid-sensitive siliciclastic bedrock have experienced chronic and episodic acidification, and some have lost acid-sensitive fish and invertebrate

species. A number of the streams on sensitive bedrock have an ANC below 20 μeq/l; the average estimated loss of ANC in these streams since pre-industrial times is 73 μeq/l. Modeling suggested that even with an immediate substantial decrease in atmospheric deposition, it would take decades for park streams to regain buffering capacity.

Valley Forge NHP

The 2003 *Baseline Water Quality Data Inventory and Analysis* report for Valley Forge NHP includes data collected from rivers, streams, creeks, springs, and ponds in the park between 1974 and 1998. Average pH values ranged from 6.0 to 8.6. The data indicated surface waters in Valley Forge NHP are not sensitive to acidification from atmospheric deposition.

Particulate Matter

Small or "fine" particles in the air, typically those less than 2.5 microns in diameter, $PM_{2.5}$, are a leading cause of human respiratory illness. Particles are present everywhere, but high concentrations and/or specific types have been found to present a serious danger to human health. Fine particles in the air are also the main contributor to human-caused visibility impairment. The particles not only decrease the distance one can see; they also reduce the colors and clarity of scenic vistas.

The current human-health based National Ambient Air Quality Standards (NAAQS) for particulate matter (set by the EPA) are for particles 10 microns or less in diameter (PM_{10}). Areas where air quality exceeds the NAAQS for PM_{10} are designated "nonattainment" for that pollutant. There are PM_{10} monitors within 25 km of all MIDN parks except Appomattox Court House NHP, Eisenhower NHS, Gettysburg NMP, and Petersburg NB. No designated PM_{10} nonattainment areas are located near MIDN parks (http://www.epa.gov/air/data/index.html).

In 1997, EPA finalized new stricter NAAQS for particulate matter based on $PM_{2.5}$. Nationwide $PM_{2.5}$ monitoring was initiated in 1999; nonattainment areas will not be designated until December 2004. There are $PM_{2.5}$ monitors within 30 km of all MIDN parks except Fredericksburg and Spotsylvania County Battlefields Memorial NMP. Monitoring data for 2000 through 2002 indicate there will be no $PM_{2.5}$ nonattainment areas near MIDN parks (http://www.epa.gov/ttn/naaqs/pm/pm25_tech_info.html).

Visibility

In 1985, in response to the mandates of the Clean Air Act, Federal and regional/state organizations established the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to protect visibility in Class I air quality areas. Class I areas are national parks greater than 5,000 acres and wilderness areas greater than 6,000 acres, that were established prior to August 7, 1977. All other NPS areas are designated Class II. The objectives of the IMPROVE program are to: establish current visibility conditions in all Class I areas, identify pollutants (particles and gases) and emission sources responsible for existing man-made visibility impairment, and document long-term trends

in visibility. The IMPROVE network is designed to assess regional visibility; standard operation does not identify individual sources that impair visibility at a monitoring site.

In 1999, there were 30 official IMPROVE sites and 40 protocol sites. Because of recently enacted Regional Haze regulations that require improving visibility in Class I areas, the number of visibility monitors has increased. Protocol sites were upgraded to full IMPROVE sites and 80 new sites were added to the IMPROVE network. While the IMPROVE program has focused on Class I air quality areas, a great deal of visibility monitoring has been conducted in Class II areas. Installation and annual operating costs for a full IMPROVE site are expensive. The ARD is currently developing a monitoring protocol for less-expensive view monitoring using a digital camera. While this type of monitoring would not be adequate for regulatory purposes, it is useful for documenting visibility conditions and trends and provides an excellent means of sharing that information with the public.

Shenandoah NP has an IMPROVE monitor on-site. Appomattox Court House NHP, Booker T. Washington NM, Eisenhower NHS, Fredericksburg and Spotsylvania County Battlefields Memorial NMP and Gettysburg NMP all have an IMPROVE monitor within 75 km. The IMPROVE sites in the region are as follows: Edwin B. Forsythe National Wildlife Refuge (NWR), New Jersey (Brigantine, BRIG1), operating since 1991; New Holland, North Carolina (Swanquarter NWR, SWAN1), operating since 2000; Arendtsville, Pennsylvania (AREN1), operating since 2001; Natural Bridge, Virginia (James River Face Wilderness Area, JARI1), operating since 2000; Shenandoah NP, Virginia (SHEN1), operating since 1988; and Washington, D.C. (WASH1), operating since 1988.

IMPROVE provides maps of visibility conditions at all monitoring sites, pie charts of the pollutants that contribute to visibility impairment at each site, and trend data for sites that have been operating 10 years or longer (http://vista.cira.colostate.edu/views/). One measurement used to report visibility is light extinction, or b_{ext}, reported in inverse megameters (Mm^{-1}). Light extinction occurs when particles in the air scatter or absorb light; extinction generally increases as particle concentrations in the air increase. Therefore, the higher the b_{ext}, the worse the visibility. The Regional Haze regulations require improvements in visibility on both the best (clearest), and the worst (haziest), days. In general, visibility is much better in the western, than in the eastern, U.S.

2002 IMPROVE data indicated b_{ext} at MIDN parks on the best visibility days ranged from 26 to 45 Mm^{-1}. On the worst visibility days, b_{ext} at Network parks ranged from 139 to 191 Mm^{-1}. These values are consistent with the 1995 to 1999 values provided in the NPS Air Atlas, i.e., 27 to 39 Mm^{-1} on the best visibility days and 171 to 190 Mm^{-1} on the worst visibility days. IMPROVE data showed that at all six sites in the region, on an annual basis, impairment in 2002 was due primarily to ammonium sulfate (sources include coal combustion and oil refineries). The remainder was due to ammonium nitrate (sources include coal and natural gas combustion and automobiles), organics (sources include automobiles), elemental carbon (sources include wood burning) and coarse mass (larger than $PM_{2.5}$; sources unknown).

Trend data are available for Edwin B. Forsythe NWR, Shenandoah NP, and Washington, D.C. The data indicate an improvement in visibility at all three sites on both the best and the worst visibility days.

Ozone

Ozone is created by a chemical reaction between oxides of nitrogen and volatile organic compounds in the presence of heat and sunlight. Some major sources of ozone-forming chemicals are motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents. High ozone concentrations cause respiratory problems in humans, and are a particular concern for those who are engaging in strenuous aerobic activity, such as hiking. Ozone also damages sensitive plant species. It injures plant leaves by causing a visible spotting or "stipple" on the upper surface of the leaves. Ozone can affect plant physiology by reducing growth, increasing susceptibility to disease, and increasing senescence.

Shenandoah NP has an ozone monitor on-site. With the exception of Appomatox Court House NHP, all other MIDN parks have a monitor within 30 km (http://www.epa.gov/air/data/index.html). The Pennsylvania counties that contain Eisenhower NHS, Gettysburg NMP and Valley Forge NHP are designated nonattainment for the existing 1-hour ozone NAAQS. There are no 1-hour ozone nonattainment areas in Virginia. EPA recently established a new NAAQS for ozone, which is based on an 8-hour ozone concentration, and this summer they published their proposed list of nonattainment areas (http://www.epa.gov/ttn/naaqs/ozone/index.html). With the exception of Appomatox Court House NHP, Booker T. Washington NM and Shenandoah NP, all MIDN parks are in proposed 8-hour ozone nonattainment areas. Based on the 1995 to 1999 ozone values contained in the Air Atlas, all MIDN parks could be nonattainment for the 8-hour ozone NAAQS.

The NPS focuses on plant sensitivity to ozone for a couple of reasons. First, ozone is a regional pollutant and is, therefore, more likely to affect park resources than other gaseous pollutants such as sulfur dioxide and nitrogen oxide which quickly convert to other compounds. Second, the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. The ARD contracted with an ozone effects expert from Cornell University to perform ozone injury risk assessments for all parks in the NPS I&M program. The risk assessments relied on the ozone concentration data provided in Air Atlas, vascular plant lists contained in NPSpecies, a list of ozone-sensitive vascular plant species developed at a 2003 expert workshop convened by the ARD (http://www2.nature.nps.gov/air/Pubs/index.htm), and the Palmer Z Index, which is used to indicate soil moisture status. Note that the ARD workshop report provides a general guide to ozone sensitivity. Differences in plant genetics, weather conditions, soil water availability, and ozone concentrations will affect whether or not a species exhibits injury in a park. In particular, studies have shown that plants will not take up ozone unless there is sufficient soil moisture. The risk assessments for the MIDN parks (Appendix 3) indicate the risk of ozone-induced foliar injury of sensitive vegetation is moderate at

Appomatox Court House NHP, Booker T. Washington NM, Petersburg NB, Richmond NBP and Shenandoah NP, while the risk is high at the rest of the Network parks.

A number of ozone injury studies have been conducted at Shenandoah NP. Foliar injury has been observed on sensitive species including milkweed (*Asclepias* spp.), black cherry (*Prunus serotina*), and yellow poplar (*Liriodendron tulipifera*). Ozone injury surveys were conducted on milkweed in Fredericksburg and Spotsylvania County Battlefields Memorial NMP from 1986 through 1991. Injury was detected each year; however, the amount and severity of injury varied by year.

The U.S.D.A. Forest Service Forest Health Monitoring (FHM) program administers a nationwide biomonitoring program in partnership with the EPA and states. Ozone injury surveys are one component of the FHM program. According to a recent publication, FHM surveys in 2000 detected ozone injury on plots in the vicinity of all parks in the MIDN with the exception of Appomatox Court House NHP and Booker T. Washington NM (Smith et al. 2003. *Environmental Monitoring and Assessment* 87:271-291). Because FHM does not provide plot location information, it is not known how close the plots are to NPS lands.

Conclusions

All MIDN parks have both wet and dry deposition monitors on-site or within 90 km. Most likely, this coverage is adequate for Network parks. The four Pennsylvania MIDN parks, Shenandoah NP, and Fredericksburg and Spotsylvania County Battlefields Memorial NMP have MDN monitors on-site or within 45 km. Mercury deposition monitoring may not be adequate for the other four Network parks.

Some streams in Shenandoah NP have documented sensitivity to atmospheric deposition. With the exception of Appomatox Court House NHP and Fredericksburg and Spotsylvania County Battlefields Memorial NMP, where sensitivity is unknown, surface waters in the rest of the MIDN parks appear well-buffered. Given the fish consumption advisories for mercury, PCBs and chlordane in Pennsylvania and Virginia, the MIDN may want to consider long-term monitoring of contaminant levels in fish or other biota.

Particulate matter is monitored within 30 km of all MIDN parks. IMPROVE sites are located within 75 km of all Network parks except Hopewell Furnace NHS, Petersburg NB, Richmond NBP, and Valley Forge NHP. If visibility impairment is a particular concern for any Network park, the MIDN may want to consider installing a digital camera to record and interpret visibility conditions.

Except for Appomatox Court House NHP, all MIDN parks have an ozone monitor on-site or within 30 km. With the exception of Appomatox Court House NHP, Booker T. Washington NM and Shenandoah NP, all MIDN parks are in proposed 8-hour ozone nonattainment areas. Based on the 1995 to 1999 ozone values contained in the Air Atlas, all MIDN parks could be nonattainment for the 8-hour ozone NAAQS. The MIDN may want to consider installing a portable ozone monitor in Appomatox Court House NHP to

determine if interpolated Air Atlas ozone estimates accurately reflect nonattainment of the NAAQS at the park (see attached *Ozone Monitoring Protocol*).

The ozone injury risk assessments funded by the NPS ARD indicate a moderate to high risk of ozone injury of sensitive vegetation in all MIDN parks. The Network may want to consider conducting foliar injury surveys in Network parks.